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An Investigation of Juvenile Salmonid Utilization of the Delta-Lakefront Area of the Adams River, Shuswap Lake

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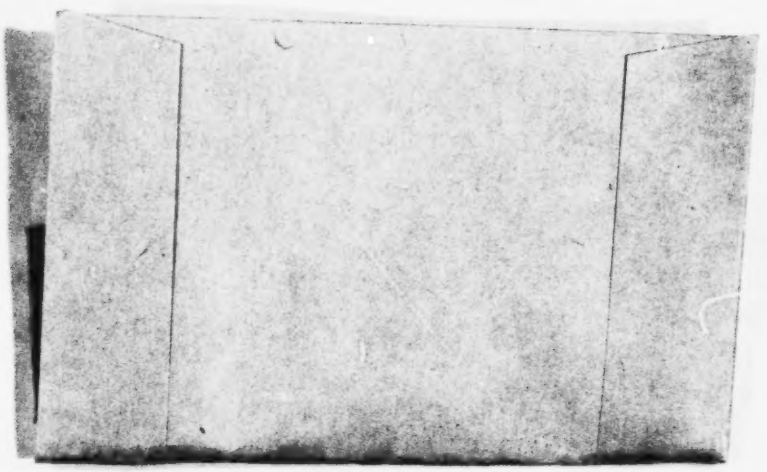

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ABSTRACT

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Investigations of juvenile salmonid utilization of the Adams River delta-lakefront were undertaken between April and November, 1977. This investigation included an assessment of rearing habitat provided by the delta-lakefront area as well as several other adjacent areas. In addition, information is provided on zooplankton and zoobenthos sampling, fish stomach content analysis and flood plain mapping.

The results of the study indicate that the delta-lakefront area is utilized by juvenile chinook and coho for a four month period of time (April-July). This period of utilization coincides with the period of time in which flood waters inundate the area. Some recommendations for land use control in this area are made.

Key words: salmon rearing habitat, foreshore utilization, zooplankton, and benthos fish stomach data

RÉSUMÉ

D'avril à novembre 1977, on a étudié l'utilisation par les saumons du delta de la rivière Adams et de la partie riveraine du lac. L'étude comporte une évaluation de l'habitat qu'offrent pour l'élevage, le delta et la partie riveraine du lac, ainsi que plusieurs autres zones adjacentes. Elle contient, en outre, des données sur l'échantillonnage du zooplancton et du zoobenthos, sur l'analyse du contenu de l'estomac des poissons et sur la cartographie de la plaine inondable.

Les résultats de l'étude indiquent que les jeunes saumons quinnats et cohos occupent la région du delta et de la partie riveraine du lac, durant une période de quatre mois (d'avril à juillet). Cette période d'utilisation coincide avec le moment où les eaux inondent la région. L'étude comporte également certaines recommandations sur la surveillance de l'utilisation des terres dans cette région.

Mots-clés: habitat d'élevage du saumon, utilisation de la plage, zooplancton et données sur les estomacs des poissons benthiques.

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1. Introduction

In October 1978, the Adams River was formally dedicated as the Roderick Haig-Brown Conservation Area. It covers an area of approximately 977 hectares on both sides of the Adams River from its source at Adams Lake to its outlet at Shuswap Lake. The Conservation Area (originally conceived in 1974) was proclaimed in April 1976 by a Provincial Government Order-in-Council under the Provincial Parks Act. This created a reserve over a corridor of private and public lands embracing the river. The purpose of this reserve was:

(i) The protection of the integrity and productivity of its spawning beds and environment.

(ii) To provide compatible recreational and educational opportunities, to enhance public knowledge and to understand a unique phenomenon in a natural state.

The Provincial Parks Branch has been assigned the responsibility to manage the Conservation Area with the aid of a Federal/Provincial Management Advisory Committee. Funds for the acquisition of the private land within the Conservation Area were provided by the Federal and Provincial Governments and the National Second Century Fund.

At present, the boundaries of the Conservation Area do not include two parcels of private property at the mouth of the Adams River:

(i) Lot A, Sec. 25, Tp. 22, Rge. 12, W6M, KDYD, Dist. Plan 20091, Kamloops Assessment District.

(ii) All the portion of S.W. ¼ of Sec. 25, which lies to the west shore of Shuswap Lake, Tp. 22, Rge. 12, W6M, except that part subdivided by Plan 20091, Kamloops Assessment District.

Both the Fisheries Management Service and Fish and Wildlife Branch have recommended that these properties be included in the Conservation Area. Subsequently, the Management Advisory Committee requested that these agencies provide Parks Branch with material that supports their position.

This study was initiated in response to that request and was undertaken to determine the salmonid utilization of the delta-lakefront area and to suggest the type of land use control necessary for the habitat in close proximity of the Conservation Area.

2. Study Area

The Adams River is a tributary of Shuswap Lake located in the south-central portion of British Columbia (Figure 1). This system, headed by Adams Lake drains via the Little River, Little Shuswap Lake and the South Thompson River. The South Thompson River joins with the North Thompson River at Kamloops and enters Kamloops Lake. Kamloops Lake drains via the Thompson River which joins the Fraser at Lytton.

The study area is primarily the delta-lakefront area of the Adams River. Several other adjacent areas in both Shuswap Lake and Little Shuswap Lake were sampled for the purposes of comparison.

3. Fisheries Resource

The Shuswap Lake system supports runs of approximately 5,100 coho (Oncorhynchus kisutch), 13,100 chinook (O. tshawytscha) and 342,000 sockeye salmon (O. nerka[1]. In addition, resident populations of rainbow trout (Salmo gairdneri), mountain whitefish (Prosopium williamsoni), Dolly Varden char (Salvelinus malma) and Kokanee (O. nerka) are present in the system.

[1] 10 year average escapement data (1968-77)

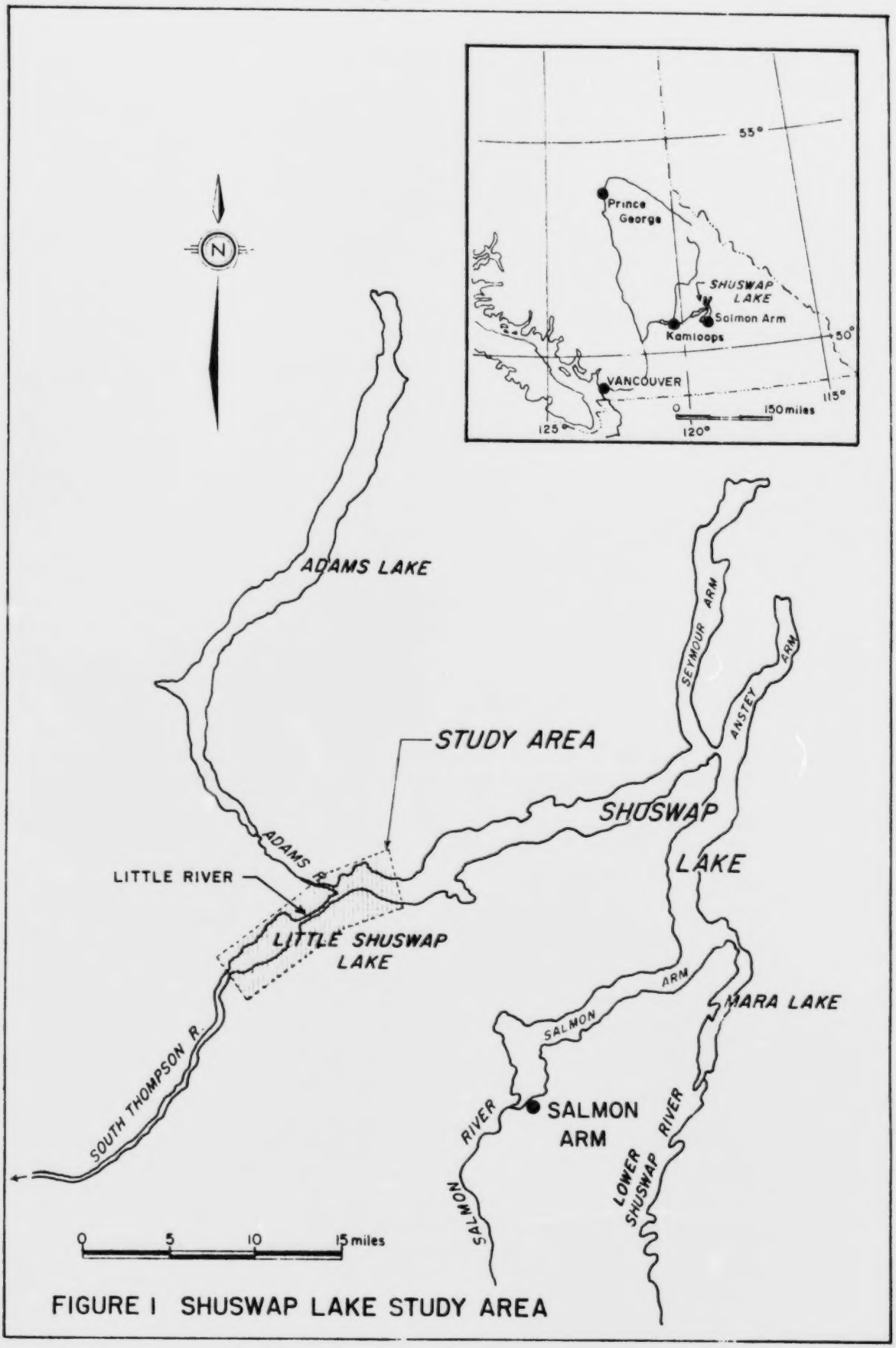

FIGURE I SHUSWAP LAKE STUDY AREA

3.1 Sockeye - The area is known primarily for its large sockeye runs. The majority of the sockeye spawn in the Adams and Little Rivers with smaller runs spawning in the Seymour, Lower Shuswap and Eagle Rivers. Sockeye populations in this system exhibit cyclic dominance (4 years) which causes wide variations in spawning populations.

3.2 Chinook - Chinook salmon spawn in most streams tributary to the Shuswap Lake system with major runs occurring in the Lower Shuswap and Adams Rivers.

3.3 Coho - Coho salmon spawn in most streams tributary to the Shuswap Lake system with major runs occurring in the Upper Adams, Bessette and Eagle Rivers.

3.4 Pink - Pink salmon spawn only occasionally in the Shuswap Lake system.

Recent escapement history for salmon spawning streams in the Shuswap Lake system is presented in Table 1.

4. Methods

4.1 Sampling Locations and Schedule

Twelve sampling stations were established on Little Shuswap and Shuswap Lake (Figure 2). These stations were sampled as outlined below:

1 - April 19-23	6 - July 5-7
2 - May 11-13	7 - July 26, 28
3 - May 25-27	8 - August 16-18
4 - June 7-9	9 - September 20-22
5 - June 21-23	10 - November 2-3

The selection of sample locations was made after reviewing previous sampling programs on the lake conducted for management purposes by Armstrong (1972) and Buxton (1976).

TABLE 1: ESTIMATES OF ANNUAL SALMON ESCAPEMENTS TO THE SHUSWAP LAKE SYSTEM BY SPECIES

Species	Name of Stream	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Sockeye	Adams River	3,983	45,908	1,315,000	280,000	4,325	40,546	1,000,000	30,000	5,100	1,500
	Upper Adams R.	0	0	25	0	25	0	25	25	25	0
	Anstey River	0	0	500	50	0	0	1,500	25	0	NR
	Eagle River	0	75	7,525	200	25	50	3,700	200	0	444
	Little River	0	6,775	222,400	12,500	75	1,500	100,000	15,000	175	8,000
	Momich River	617	0	200	25	750	0	25	0	3,000	30
	Scotch Creek	126	3,395	6,300	750	0	7,500	3,900	25	38	13,636
	Seymour River	3,870	7,327	14,375	15,000	3,500	3,500	35,000	30,000	8,500	6,018
	Lower Shuswap R.	25	1,500	29,000	7,500	200	7,452	75,000	15,000	82	7,500
	Middle Shuswap R.	0	0	4,559	200	0	0	3,500	25	0	32
	Sinmax River	0	50	200	3	25	69	200	0	25	70
Chinook	Adams River	3,500	5,000	1,500	750	1,900	16,500	1,500	1,500	400	1,700
	Upper Adams R.	0	0	0	0	0	0	150	0	0	0
	Bessette R.	0	0	25	25	25	0	25	25	0	15
	Eagle River	200	400	300	750	300	350	400	400	0	756
	Little River	400	200	750	200	200	200	300	400	100	600
	Salmon River	275	200	200	400	0	0	200	150	50	320
	Scotch Creek	25	0	0	0	0	0	0	0	0	0
	Seymour River	0	25	0	0	0	0	0	0	0	25
	Lower Shuswap R.	7,500	7,500	7,500	7,500	4,500	9,000	10,000	15,000	2,500	9,500
	Middle Shuswap R.	400	500	750	750	300	400	750	750	400	550
Coho	Adams River	400	750	400	300	200	300	150	200	10	338
	Upper Adams R.	NR	P	P	P	P	P	150	75	NR	150
	Anstey River	25	25	25	0	25	25	25	25	25	NR
	Bessette River	1,500	1,500	750	750	2,000	750	1,500	750	25	70
	Eagle River	1,500	750	1,500	1,500	1,200	1,800	3,500	1,500	1,100	2,694

TABLE 1: ESTIMATES OF ANNUAL SALMON ESCAPEMENTS TO THE SHUSWAP LAKE SYSTEM BY SPECIES (cont'd.)

Species	Name of Stream	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Coho (cont'd)	Tappen Creek	25	25	25	25	25	25	0	25	1	12
	Momich River	75	200	NR	75	25	25	25	25	0	20
	Salmon River	1,250	1,500	750	1,500	2,000	400	1,500	750	900	1,580
	Scotch Creek	25	0	200	25	25	25	25	25	5	0
	Seymour River	0	NR	NR	NR	NR	NR	NR	2	1	25
	Lower Shuswap R.	400	750	400	75	300	250	100	200	40	100
	Middle Shuswap R.	400	750	400	400	400	500	500	200	60	594
	Sinmax River	400	200	200	213	104	165	200	75	25	40

P - Present
NR - None Recorded

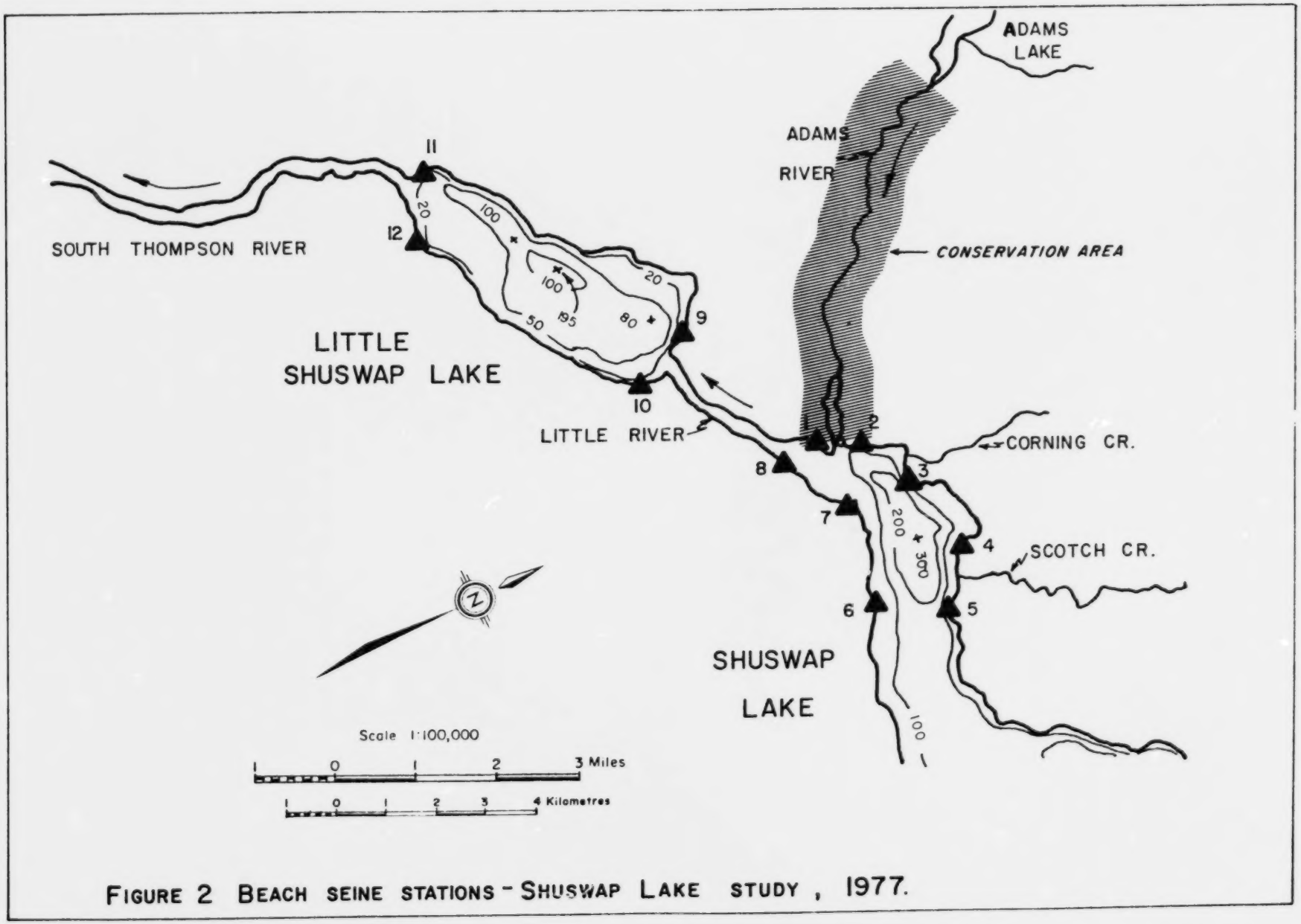

FIGURE 2 BEACH SEINE STATIONS - SHUSWAP LAKE STUDY, 1977.

4.2 Fish Distribtuion Residence, and Age Analysis

During each sampling period every station was checked to assess changes in density of juvenile salmonids in the foreshore areas using a 20 x 2 m beach seine. Seine sets were made at approximately the same time on each sampling day in order that catches at each station would be comparable throughout the study. A number of sets were made at stations at different times during a 24 hr. period in order to detect any diel variability in juvenile abundance.

As part of this study to determine residence time, a mark-recapture experiment was undertaken at sampling stations 1 and 2. All juvenile chinook salmon seined at these sites on April 19-23 and May 11-12 were marked by removal of part of the dorsal or ventral portion of the caudal fin. All chinook salmon seined at any of the 10 sampling sites on subsequent sampling dates were examined for evidence of this caudal fin clip.

4.3 Zooplankton, Zoobenthos and Stomach Content

4.3.1 Zooplankton

Ten meter vertical hauls were made at stations 2, 4, 6 and 19 using a single Wisconsin net with a mouth diameter of 50 cm and a pore opening of 77µ micron. Samples were preserved in 5% formalin and shipped to the Fisheries and Marine Service laboratory for identification to genus. Catch results are expressed as individuals per litre. Samples were collected during sample periods 2 and 6.

4.3.2 Zoobenthos

Dredge samples were collected at 2 and 5 m depths using a Ponar dredge at stations 2, 4, 6, and 10 during sampling periods 2 and 6. Samples were preserved in 5% formalin and transferred to the Fisheries and Marine Service laboratory in Vancouver where they were immediately sieved using 250 micron mesh screens. The residue was preserved in 5% formalin. Samples were rinsed overnight to remove formalin and sorted with a stereo-miscroscope to genus.

4.3.3 Stomach Content

Ten chinook salmon fry were collected at stations 2, 4, 6 and 10 from the seining catches during regular seining activities in sample period 2. These fish were preserved in 5% formalin and transferred to the Fisheries and Marine Service laboratory where the stomachs were removed and contents sorted with a stereo-microscope to genus.

4.4 Flood Mapping

Lake levels in Shuswap Lake were also examined with reference to the identified parcels of land to assess the degree of flooding. Lake level data were obtained from Canada Water Survey records dating back to 1970. Several transects were established on both properties, by means of levels, to determine the degree and timing of the flooding which occurred.

4.4 Temperature Profiles

Temperature profiles were taken at two stations in Shuswap Lake (Figure 2) during sampling periods 1 - 7 and 9 using a YSI model 43 Tele-thermometer. In addition, water temperatures were recorded at each seining site on each sampling occasion using a calibrated band thermometer.

5. Results

5.1 Fish Distribution Residence, and Age Analysis

5.1.1 Fish Distribution

Numbers of juvenile salmon captured during beach seining operations in Shuswap Lake are shown in Figures 3a, b, and c. While large numbers of salmon were present at most sampling stations throughout April, May and June (with the exception of stations 5 and 9) few salmon were found at any of the seining sites after July 5.

The majority of juvenile salmon seined were chinook salmon (Figure 3), therefore it was decided to examine catch results for this species in detail. Figure 4 shows the numbers of juvenile chinook salmon taken at grouped stations.

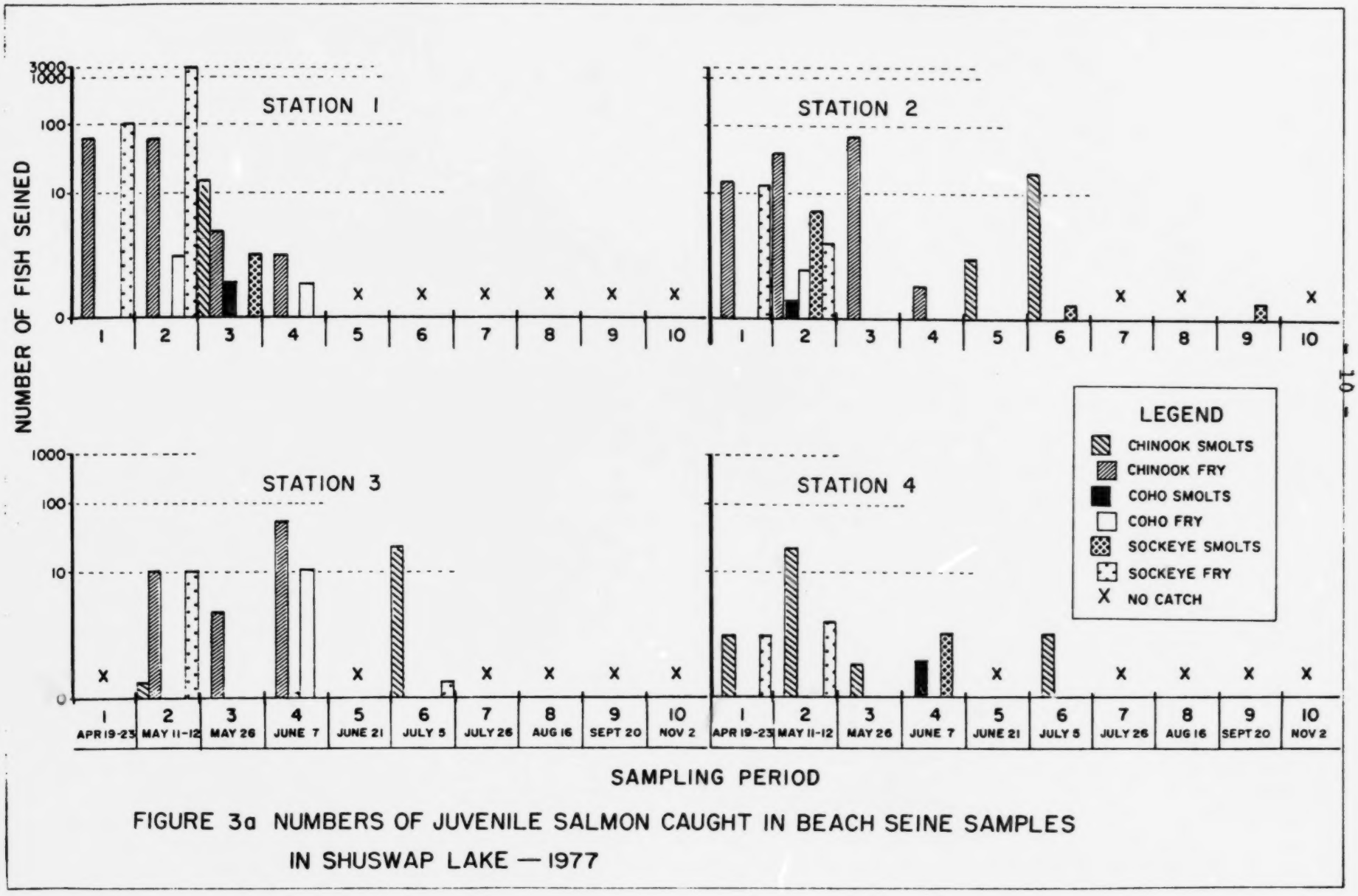

FIGURE 3a NUMBERS OF JUVENILE SALMON CAUGHT IN BEACH SEINE SAMPLES IN SHUSWAP LAKE — 1977

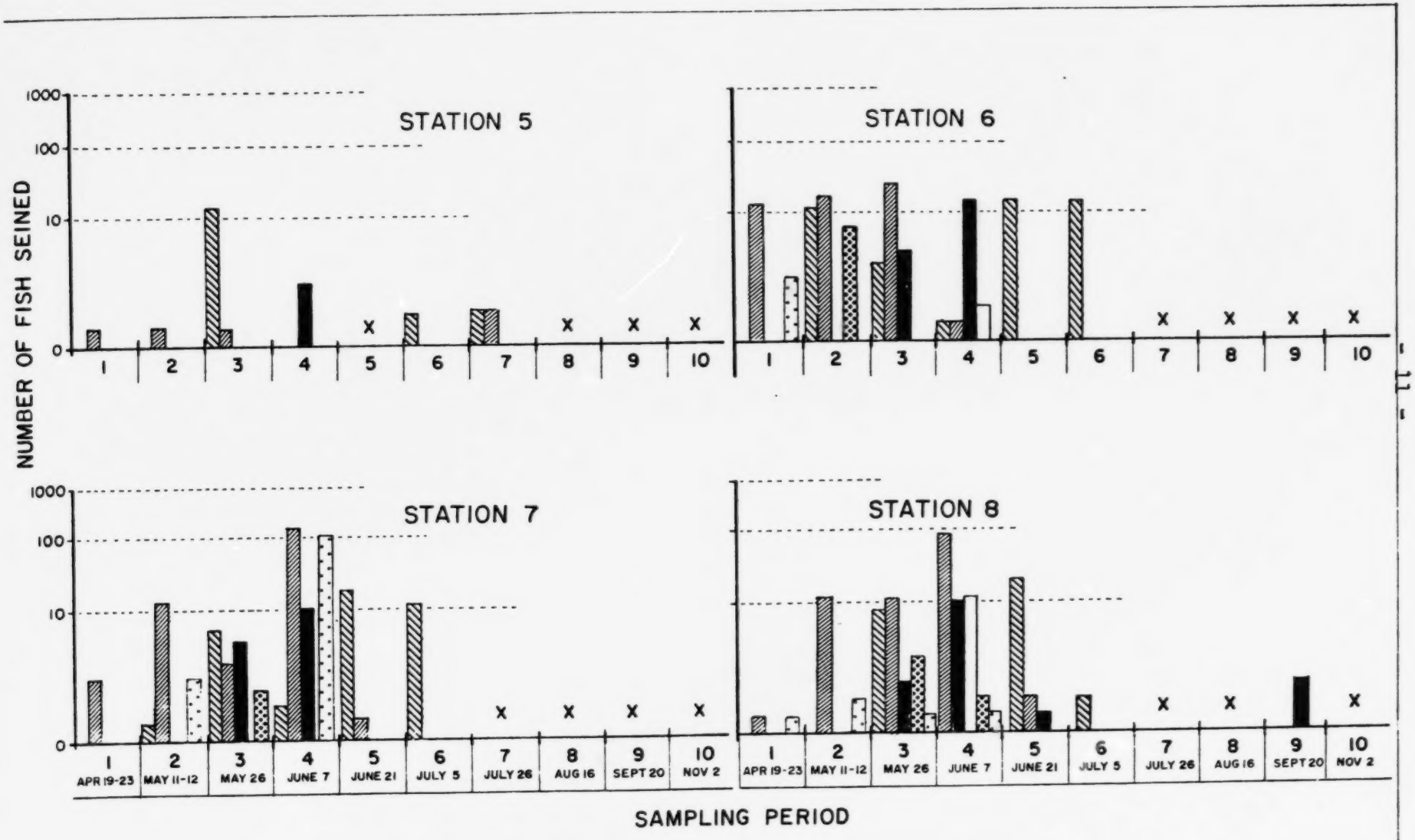

FIGURE 3b NUMBERS OF JUVENILE SALMON CAUGHT IN BEACH SEINE SAMPLES IN SHUSWAP LAKE — 1977

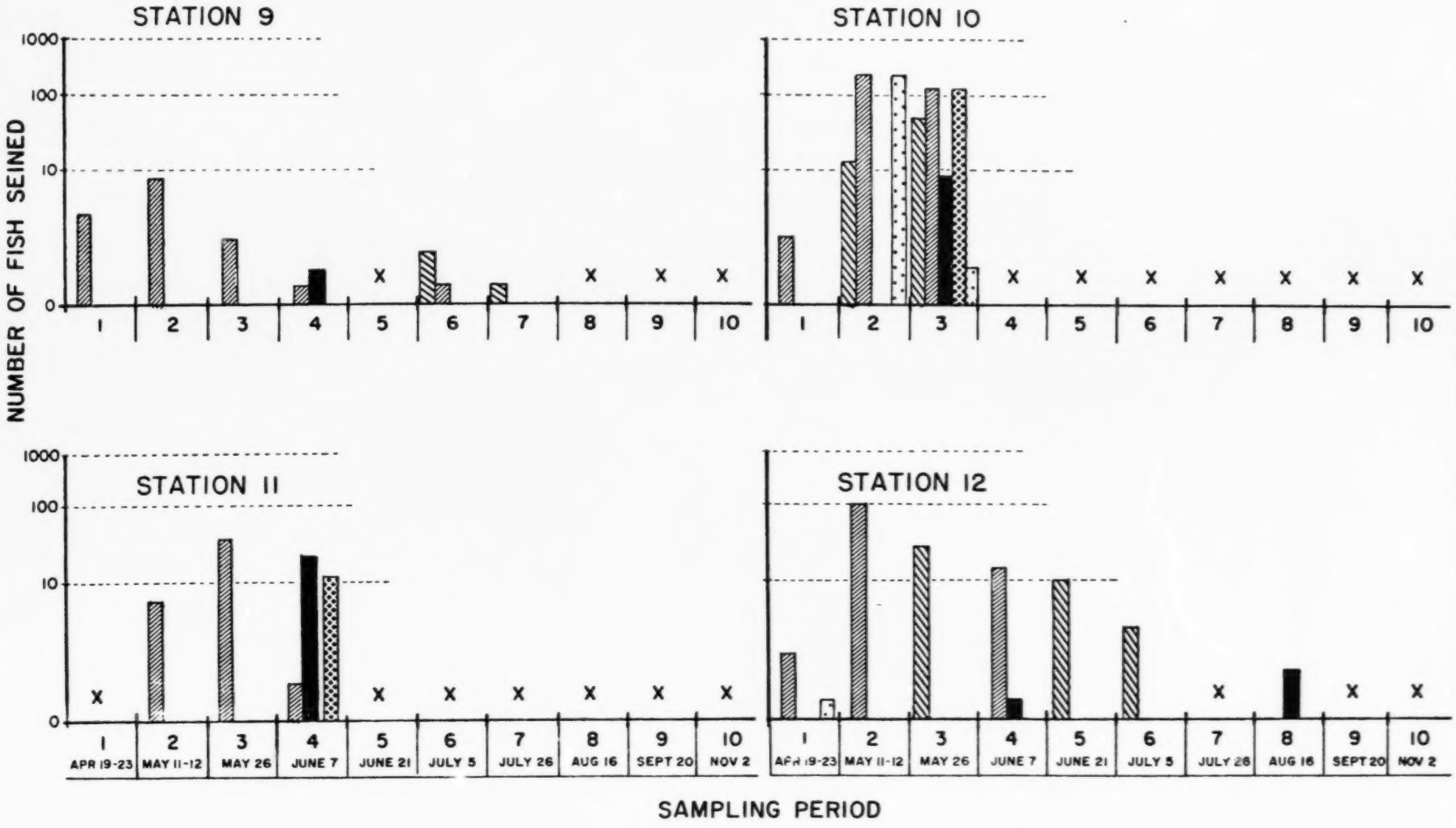

FIGURE 3c NUMBERS OF JUVENILE SALMON CAUGHT IN BEACH SEINE SAMPLES IN SHUSWAP LAKE — 1977

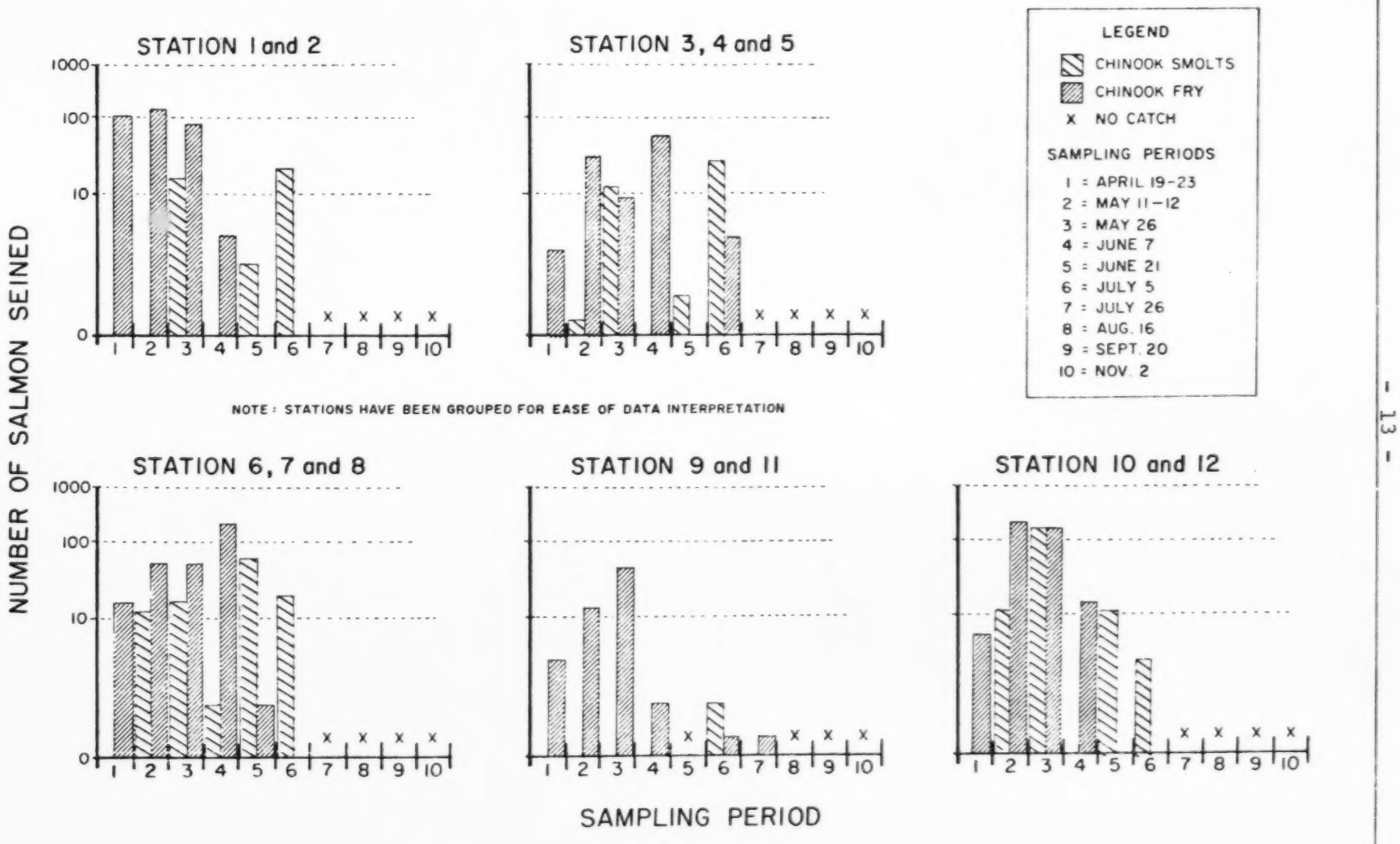

FIGURE 4 NUMBER OF JUVENILE CHINOOK SALMON CAUGHT IN BEACH SEINE SAMPLES IN SHUSWAP LAKE — 1977

Numbers of chinook salmon caught (expressed as catch per set) at the 12 beach seining stations indicate that:

Stations 1 and 2

During the first three sampling periods, (April 19-23, May 11-12, May 26) large numbers of chinook salmon fry were present (100, 135 and 86 fry were seined on each respective sampling date). Less than one-tenth as many fry were caught during the next sampling period (June 7) and none were taken on any subsequent sampling date.

Moderate numbers of chinook smolts (20 and 34 fish) were caught on May 26 and July 5 respectively. No chinook smolts were found at stations 1 or 2 after the July 5 sampling date.

Stations 3, 4 and 5

Numbers of chinook fry caught increased from 5 to 45 during the time between April 19 and May 11 sampling period, decreased to 9 on the May 25 sampling date and increased again to 71 fish on June 7. No fry were caught during the June 21 sampling period, and only 6 were taken on July 5. No chinook fry were seined at these stations after July 5.

While only 17 chinook smolts were captured at sites 3, 4 and 5 during the first 5 sampling dates, 40 were taken by beach seining at these stations on July 5. No smolts were captured at these stations after the July 5 sampling date.

Stations 6, 7 and 8

Numbers of chinook salmon captured increased from 21 on April 19-23 to 311 on June 7. Only 3 fry were seined on July 21 and none were caught on any subsequent sampling dates.

Stations 9 and 11

Numbers of chinook salmon fry captured varied from 60 to 62 fish during the first three sampling periods. On the June 7-9 seining trip only 3 chinook fry were caught and neither fry nor smolts were collected at these stations after July 26.

A total of four chinook smolts were seined at sites 9 and 11 during the study. Three of these were captured on July 5 and one was taken on July 26.

Stations 10 and 12

Numbers of chinook fry increased during the first two sampling periods to 354 fish taken in two seine sets on May 11-12. Numbers of fry captured decreased considerably during the next two sampling periods and only 22 were found at these stations on June 7. After June 7 chinook fry were no longer captured at stations 10 and 12.

The maximum number of smolts (113) captured at these sampling sites were seined on May 11-12. Thereafter smaller numbers of smolts were seined until the July 26-28 sampling period when salmon were no longer captured at these sampling stations.

5.1.2 Residence

Fin-clipping experiments conducted during time periods 1 and 2 resulted in the recapture of 16 out of 98 chinook fry marked at site 1 during the period April 19-23 but only 1 fish out of 105 marked at sites 1 and 2 during the May 11-13 sampling period.

5.1.3 Age Analysis

Analysis of scales taken at the time when fish were fin-clipped indicated that both age 0+ and age 1+ (fish that have overwintered in the Shuswap system) chinook were present in the study area at the time of this investigation. Insufficient numbers of scale samples were taken, however, to allow accurate assessment of the relative proportion of each age class of fish in Shuswap Lake chinook populations.

5.2 Zooplankton, Zoobenthos and Stomach Content

5.2.1 Zooplankton

Copepods make up the majority of the limnetic plankton especially during the May sampling period (Table 2).

The most predominant copepod was Diaptomus ashlandi although Epischura nevaderises increased in numbers by the September sampling period. Cyclops bicuspidatus appeared in large numbers only during the May time period and only at station 2. Predominant cladocerans were Bosmina spp. and Daphnia spp.

5.2.2 Zoobenthos

The results of the benthic sampling program are presented in Tables 3 and 4. Crustaceans and insects' larvae were the predominant benthic organisms. Crustacean populations were dominated by harpacticoid copepods while insect populations were comprised mainly of chironimids.

Average density of benthic invertebrates at 2 m depths in May and September were 3,171 organisms /m^2 and 40,198 organisms /m^2 respectively while the density at 5 m depths was 15,953 organisms /m^2 and 47,650 organisms /m^2 respectively.

5.2.3 Stomach Content

Results of stomach content analysis for the May time period are given in Table 5. The results indicate that chinook fry were feeding on food items of both planktonic and benthic origin. The major prey item in most cases appears to be cladocerans (present in both plankton and benthic samples). Dipterans were present in all stomach samples. Unfortunately, the number of samples taken for stomach analysis at later dates were insufficient to allow comparison with these results.

5.3 Flood Mapping

Investigations of the degree of flooding of private properties along the delta-lakefront of the Adams River indicates that the highest elevation on these properties if 1,145.6 feet geodetic. When compared to lake level information (Table 6) available

TABLE 2: COMPOSITION OF ZOOPLANKTON SAMPLES IN SHUSWAP LAKE (1977)

	STATIONS							
	2		4		6		10	
Species (ind/l)	May	Sept.	May	Sept.	May	Sept.	May	Sept.
Cladocera								
Leptodoridae	--	0.01	0.01	--	--	0.01	--	--
Holopedidae	--	0.23	--	0.07	--	--	--	0.01
Daphnidae	0.20	1.60	0.02	1.16	1.44	0.54	0.25	0.15
Bosminidae	0.69	0.05	0.39	0.22	0.36	0.01	0.30	0.04
Copepoda								
Calanoida								
Temoridae	--	0.28	--	0.43	--	0.05	--	0.04
Diaptomidae	5.69	2.94	3.08	3.23	6.31	0.35	2.36	0.86
Cyclopoida								
Cyclopidae	3.61	--	0.28	0.03	0.25	--	0.66	0.02
Total (ind/l)	10.19	5.11	3.96	5.14	8.36	0.96	3.57	1.12

TABLE 3: COMPOSITION OF BENTHIC SAMPLES IN SHUSWAP LAKE (1977)

	Sta. 2				Sta. 4				Sta. 6				Sta. 10			
	May		Sept.		May		Sept.		May		Sept.		May		Sept.	
Species	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M
Nematoda	42	128	88	208	11	32	48	44	137	172	128	896	16	272	232	176
Annelida	12	360	160	320	29	8	504	68	15	24	833	656	64	160	120	92
Mollusca	1	24	4	48	5	-	-	-	-	64	32	-	18	128	-	12
Arthropoda																
Crustacea	14	72	816	2592	6	56	344	102	97	244	1312	1856	16	528	352	224
Insecta	221	872	440	1360	156	204	2424	708	-	1060	2432	3552	-	-	840	324
Arachneida	8	24	-	16	-	4	8	-	8	11	80	32	8	-	8	-
Total	298	1480	1508	4544	207	304	3328	922	257	1575	4817	6992	122	1088	1552	830
Org/m^2	4276	21238	21640	65206	2970	4362	47757	13230	3688	22601	69124	100335	1750	15612	22271	11828

TABLE 4: COMPOSITION OF CRUSTACEANS AND INSECTS IN BENTHIC SAMPLES IN SHUSWAP LAKE

	Sta. 2				Sta. 4				Sta. 6				Sta. 10			
	May		Sept.		May		Sept.		May		Sept.		May		Sept.	
Species	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M	2M	5M
Crustacea																
Malacostraca																
Amphipoda	-	-	-	32	-	-	-	-	12	4	-	-	-	-	-	-
Ostracoda	3	16	240	352	3	16	16	-	61	116	1120	992	4	160	56	160
Copepoda																
Calanoida	-	-	4	-	-	-	8	8	-	-	-	16	-	-	16	-
Cyclopoida	-	-	36	112	-	-	32	12	4	4	100	96	-	-	40	12
Harpacticoida	10	48	388	1920	-	40	32	20	16	100	-	496	10	352	128	16
Branchiopoda																
Cladocera	1	8	148	176	3	-	256	62	4	20	32	256	2	-	112	36
Insecta																
Diptera																
Chironomidae	213	824	428	1280	155	204	2160	672	850	1028	3488	2432	290	896	840	256
Others	4	48	-	16	1	-	264	36	27	28	64	-	-	48	-	64
Ephemeroptera	2	-	12	64	-	-	-	-	2	4	-	-	-	-	-	-
Trichoptera	2	-	-	-	-	-	-	-	6	-	-	-	-	-	-	4

TABLE 5: OCCURRENCE OF FOOD ITEMS IN STOMACHS OF CHINOOK FRY

Organisms Present in Stomachs	Station 2 Food Item Occurrence			Station 4 Food Item Occurrence			Station 6 Food Item Occurrence			Station 10 Food Item Occurrence		
	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs
Arthropoda												
Cladocera	X	X	X	X	X	X	X	X	X	X	X	X
Copepoda												
Calanoida	X	-	-	X	-	X	X	-	-	X	-	X
Cyclopoda	X	-	X	X	-	X	X	-	X	X	-	X
Harpacticoida	-	X	-	-	X	-	-	X	-	-	X	-
Malacostraca												
Amphipoda	-	X	-	-	-	-	-	X	-	-	-	-
Insecta												
Collembolla	-	-	X	-	-	-	-	-	X	-	-	X
Coleoptera	-	-	X	-	-	-	-	-	X	-	-	X
Diptera	-	X	X	-	X	X	-	X	X	-	X	X
Ephemoptera	-	-	-	-	-	-	-	X	-	-	-	-
Homoptera	-	-	-	-	-	X	-	-	-	-	-	-
Hymenoptera	-	-	-	-	-	X	-	-	X	-	-	X
Tricoptera	-	X	X	-	-	-	-	X	X	-	-	X

TABLE 5: OCCURRENCE OF FOOD ITEMS IN STOMACHS OF CHINOOK FRY (cont'd.)

Organisms Present in Stomachs	Station 2 Food Item Occurrence			Station 4 Food Item Occurrence			Station 6 Food Item Occurrence			Station 10 Food Item Occurrence		
	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs	Plankton	Benthos	Stomachs
Chelicerata Aractoneida	-	X	X	-	-	-	-	X	-	-	-	-
Total Benthic/Stomach Content Overlaps		5			2			3			2	
Total Plankton/Stomach Content Overlaps		2			3			2			3	

TABLE 6: DEGREE OF FLOODING AT DELTA-LAKEFRONT PROPERTY

Degree of Flooding	Year	Time of Flooding	No. Days Flooded
100% flooding (El.-1145.6 ft.)	1970	None	None
	71	None	None
	72	June 8-27	20
	73	None	None
	74	June 26-29	4
	75	None	None
	76	None	None
88% flooding (El.-1140.0 ft.)	1970	None	None
	71	June 14-17	4
	72	June 2-July 7	36
	73	None	None
	74	June 21-July 12	22
	75	None	None
	76	None	None
40% flooding (El.-1142.0 ft.)	1970	None	None
	71	June 1-July 6	36
	72	May 29-July 25	57
	73	None	None
	74	June 16-July 25	40
	75	June 15-July 11	27
	76	June 20-July 23	34

from Water Survey of Canada records this level would be exceeded in both 1972 (20 days) and 1974 (4 days).

Along the foreshore of these private properties a small berm exists at an elevation of 1,142 feet geodetic. During the period of record (1970-1976) this berm would be topped an average of 28 days each year. This represents flooding of approximately 40% of the area of these private properties.

5.4 Temperature Profiles

Temperature profiles recorded in Shuswap Lake are given in Figure 5. These data show the gradual development of a thermocline in the lake by July 5 at both temperature profile stations. The profile taken September 20 shows the beginning of a trend toward isothermal conditions seen in the profiles taken on April 19.

6. Discussion

6.1 Fish Distribution, Residence, and Age Analysis

Fish distribution studies undertaken in this investigation indicate that juvenile chinook salmon were present along most of the shoreline of the Shuswap Lake study area from mid-April until mid-July. Foreshore areas in the immediate vicinity of the Adams River (stations 1 and 2) and on the south side of Shuswap and Little Shuswap Lakes (stations 6, 7, 8, 10 and 12) supported the largest number of chinook salmon juveniles. Both fry and smolts seemed to prefer these areas of the study area. Seining sites 3, 4, 5, 9 and 11 supported fewer young salmon during the sampling period.

This information suggests that following their initial entry into the lake, chinook salmon fry remain in the vicinity of their natal streams for a short period of time, then migrate either out of the Shuswap Lake system via the Little River or along the south shoreline of Shuswap Arm and Little Shuswap

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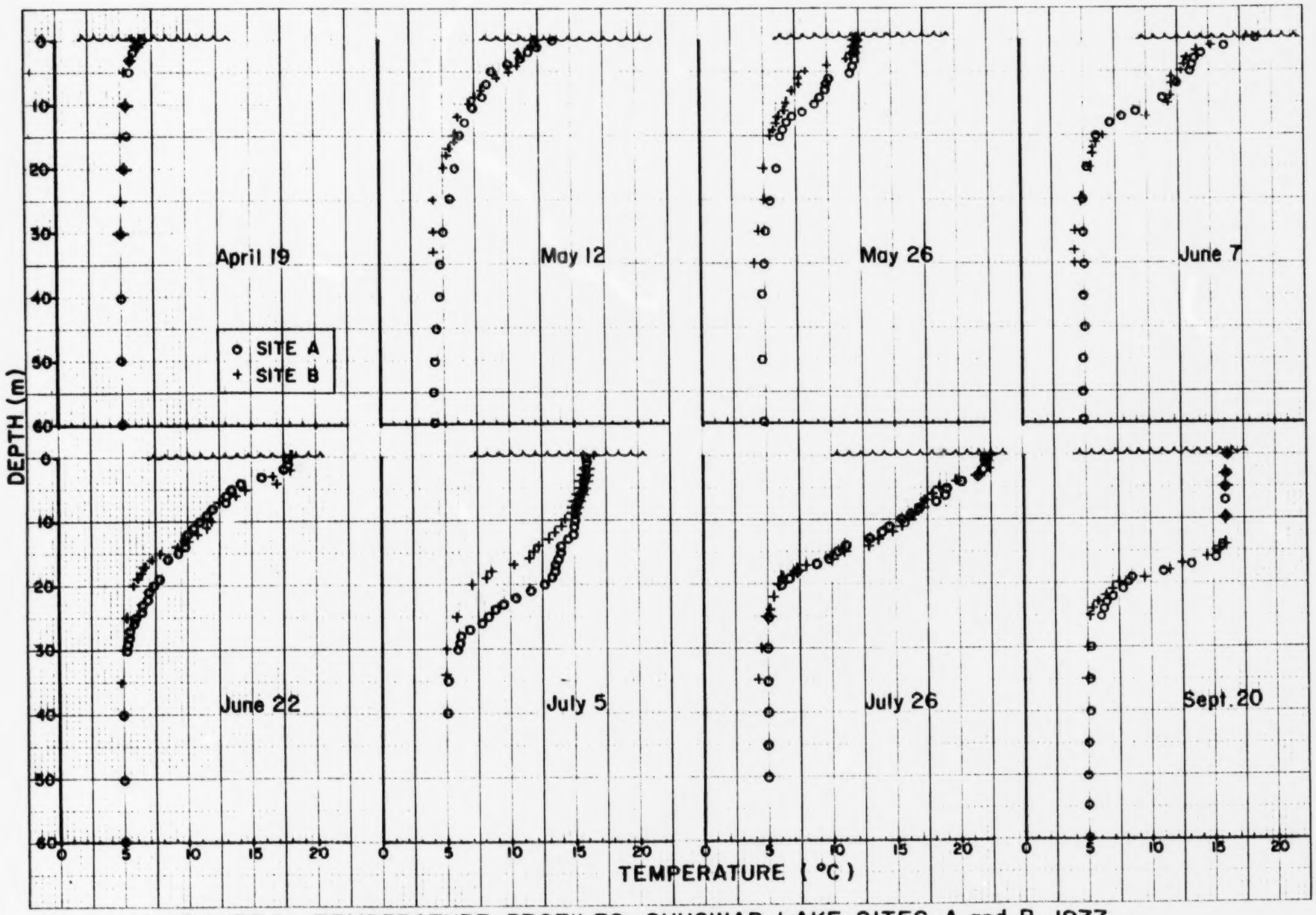

FIGURE 5: TEMPERATURE PROFILES, SHUSWAP LAKE SITES A and B, 1977.

Lakes. Utilization of the northern shoreline of the study area by rearing or migrating juvenile salmon appears to be minimal. These same conclusions have been expressed by Armstrong (1972). In addition, work by Brannon (1972) indicates a heavy utilization of the southern shoreline of Shuswap Arm.

Some suggestions for preference by juvenile salmon of the southern shoreline areas of the study area may include:

(i) greater availability of food as a result of more extensive littoral habitat for benthic invertebrate production,

(ii) prevailing onshore winds or currents which tend to concentrate planktonic organisms in southern foreshore areas.

In addition, Armstrong (1972) conjectured that gradually decreasing lake levels in the Shuswap system may leave some northern shoreline areas inaccessible to rearing juvenile salmon as the summer progresses.

Water temperatures may also be an important factor in the disappearance of juvenile chinook salmon from foreshore areas of Shuswap Arm. Average temperatures recorded at seining sites and during the temperature profile data collection (at a depth of 2 m - equivalent to depth of beach seine used) have been compared with abundance of juvenile chinook salmon observed in the study area during each sampling period (Table 7). These data suggest that nearly all salmon leave Shuswap Arm and Little Shuswap foreshore study areas as soon as water temperatures exceed 16.1°C.

In addition to temperature effects, timing of juvenile displacement from foreshore areas may also be determined by lake levels and food availability, as suggested in the evidence for preference by young salmon of south-shore rearing areas in the study area. Thus, diminishing littoral area and food supply accompanying decreasing lake levels in the summer may stimulate young salmon to leave the foreshore and possibly the lake.

TABLE 7: Comparison of Average Temperatures Recorded at Seining Sites (1/2 m) and Temperature Profile Sites (2 m) with Total Numbers of Juvenile Salmon Seined During Each Sampling Period

Sampling Period	1	2	3	4	5	6	7	8	9	10
Temp. (°C) (1/2 m)	6.9	10.2	11.1	16.7	15.5	15.9	22.6	21.7	15.8	9.8
Temp. (°C) (2 m)	6	11.9	12.1	14.2	17.8	16.1	22.1		16.2	
No. Chinook Fry	140	611	337	413	3	7	0	0	0	0
No. Chinook Smolts	0	28	169	3	97	113	1	0	0	0
Total No. Salmon	140	639	506	416	100	120	1	0	0	0

While the majority of juvenile chinook salmon appear to migrate out of the study area prior to the end of July, scale analysis of fish used in fin-clipping experiments suggests that some chinook salmon overwinter in the lake or tributary systems. Seining results indicate that chinook salmon no longer utilize littoral feeding areas, used during the spring, after July 26. The question then arises; where do these salmon fry spend the fall and winter months?

It is possible that juvenile chinook migrate into pelagic areas of the lake to avoid the high water temperatures prevalent in littoral areas during the summer and to exploit populations of benthic and planktonic invertebrates no longer available in exposed shoreline areas. However, information from the International Pacific Salmon Fisheries Commission mid-water trawls does not indicate the presence of any juvenile chinook with the sockeye in the pelagic areas of the lake.

Armstrong (1972) has suggested that juvenile chinook salmon in Shuswap Lake exhibit diel inshore-offshore migrations in late summer in response to fluctuating water temperatures in littoral areas and receding lake levels. As these fish become larger they may range farther and tend less toward schooling behavior than they did when they were smaller. These factors would make the majority of overwintering salmon unavailable to the beach seine used in this study. It is possible, however, that if modified beach seining, purse seining, trawling or trapping methods were employed in areas where juvenile salmon were caught during the spring some overwintering fish might be caught throughout the fall and winter months. Any such additional evidence for overwintering would serve to strengthen the argument for preserving shoreline areas, such as the foreshore region at the mouth of the Adams River, and the south beaches of the study area which appear to be essential to the production of young salmon.

6.2 Zooplankton, Zoobenthos and Stomach Content

6.2.1 Zooplankton

Quantitatively the plankton abundance at the stations sampled in the lake appears to be low. The total crustaceans however are comparable to other oligotrophic lakes in B.C. (Table 8).

TABLE 8: COMPARISON OF ZOOPLANKTON ABUNDANCE IN SOME B.C. LAKES

Lake	Total Crustacean Zooplankton Abundance, Ind/cm^2
Morice	0.37 - 8.96
Lakelse	0.01 - 16.49
Shuswap	0.96 - 10.19
Okanagan	101 - 188
Kalamalka	136
Skaha	236 - 238

1) Patalas et al. 1973
2) Cleugh et al. 1978
3) Cleugh et al. 1979

This species composition information differs from that reported in Goodlad et al. (1974) in which they state that Daphnia thorata was the most abundant species. This difference may be due to the fact that the sampling for this study was conducted in nearshore areas as opposed to open water areas.

6.2.2 Zoobenthos

Considerable variation occurred in density of benthic organisms at each site. The highest benthic populations occurred at stations 2 and 6. These stations are located near the outlet of the Adams River and may be influenced by the flow created by the river inflow to the lake and general outlet conditions which exist in this area. In addition, production in this area may be enhanced by nutrient input from the salmon carcasses from the Adams River spawning areas.

6.2.3 Stomach Content

Chinook fry feed on a variety of organisms from both benthic and planktonic sources. The major overlap occurred with cladocerans which were present in the benthic and planktonic areas. A high occurrence of insects in the stomach contents of chinook fry was evident at each station.

6.3 Flood Mapping

Investigation of the degree of flooding of private properties along the delta-lakefront areas of the Adams River has shown that these properties have been inundated by Shuswap Lake an average of 28 days per year over the period of records (1970-76). The highest point of land on either piece of property lies at an elevation of 1,145.6 feet. This level was exceeded in both 1972 and 1974 by high lake levels and is well below the minimum flood construction level of 1151.6 feet set by the Water Investigations Branch. The period of maximum inundation takes place during June and partially coincides with the periods of heaviest utilization of foreshore areas by juvenile chinook salmon. Development of flood proof recreation facilities on this land would therefore entail dyking of the foreshore area to prevent rising lake waters from disrupting the development. This would result in the loss of

spring rearing habitat currently utilized by juvenile salmon following their descent from incubation areas in the Adams River. This type of activity could result in creation of small impoundments which would trap juvenile salmon as the water recedes. The effect on salmon populations of this loss of rearing habitat is difficult to determine in a lake system as large as the Shuswap.

7. Conclusion

It becomes apparent from the results of this study that the delta-lakefront area of the Adams River is utilized extensively for a four month period of time by juvenile chinook salmon. This period of utilization is approximately coincidental with the period of time at which flood levels inundate the foreshore so development activities on the upland or foreshore area could have a serious impact on this area as a rearing habitat.

8. Recommendation

To reduce the potential of damage to this unique habitat area, it is recommended that some form of land use control be assured on the upland area and that no alteration of areas below the high water elevation be approved. This could be accomplished by including those areas of the delta-lakefront properties that flood within the Conservation Area or by means of zoning restrictions (either Regional District or Provincial) provided co-operation and long term protection are the recognized goals by all agencies involved in controlling land use development.

LITERATURE CITED

Armstrong, R. 1972. Observation of chinook fingerlings in the Shuswap Lake and Thompson River System in 1971. D.F.E. Fish. Mar. Ser. Memorandum. Feb. 25, 1972. 20 pp.

Brannon, E.L. 1972. Mechanisms controlling migration of sockeye salmon fry. IPSFC Bull. XXI.

Buxton, J.D. 1976. Shuswap Lake Juvenile Chinook Coded-Wire-Tagging Program. 1976. Memorandum Report unpublished.

Cleugh, T.R., Graham, C.C. and McIndoe, R.A. 1978. Chemical, Biological and Physical Characteristics of Lakelse Lake, B.C. D.F.E. Fish. Mar. Ser., M.S. Rep. 1472.

Cleugh, T.R., and Lawley, B.C. 1979. The Limnology of Morice Lake Relative to the Proposed Kemano II Power Development. D.F.E. Fish. Mar. Serv. Special Publication.

Goodlad, J.C., Gernes, T.W., and Brannon, E.L. 1974. Factors affecting sockeye salmon growth in four lakes in the Fraser River system. J. Fish. Res. Board Can. 31:871-892.

Patalas, K., and Salki, A. 1973. Crustacean plankton and the eutrophication of lakes in the Okanagan Valley, British Columbia. J. Fish. Res. Bd. Can. 30:519-542.

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